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Beyond the stand: Reviewing landscape fragmentation dynamics on biodiversity and ecosystem services in Southeast Asia

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Forest and agriculture landscapes dominate across Southeast Asia. Agricultural systems are highly diverse ranging from traditional swidden and agroforestry, to the more recent intensive industrial oil palm plantations. These management approaches have fabricated distinct fragmented landscapes that could yield significantly varying impacts on biodiversity and ecosystem services. Our systematic styled review compares fragmentation in industrial oil palm (IOP) and smallholder agroforestry (SH) landscapes, and how this influences biodiversity (soil fauna, avifauna, and vegetation) and ecosystem services in Southeast Asia. Two literature searches were carried out capturing fragmentation studies in IOP and SH settings. After devising a selection criteria, we identified relevant studies, assessed the type of landscape metrics used, and synthesized research findings.

After screening 2301 studies, 26 passed our selection criteria; avifauna was the most widely studied group for biodiversity outcomes (n=9), and isolation was the most popular landscape measure (n=13). 50% of studies focused on IOP in Malaysia and none focused on IOP in Indonesia despite being the world's largest oil palm producer. We found too few studies on interactions between ecosystem services and landscape dynamics to draw meaningful comparative findings. Studies in SH systems provided cases of well-connected and diverse forest-agriculture mosaics that successfully supported all biodiversity. In IOP landscapes, we found mixed effects, which depended on the dispersal range of species, their adaptive ability along habitat gradients, and how actors managed forest fragments.

Land use research is dominated by land use level comparisons, and rarely do studies measure landscape interactions, which is evident in the lack of studies in our review. Few studies addressed more complex, yet important measures, such as the permeability and pattern of the landscape matrix[1]. Assessing fragmentation processes over time addresses the resilience of landscapes to different agricultural practices[1], and the critical threshold that determines the recoverability of forests and biodiversity[2]. Understanding these underlying recovery mechanisms contributes to supporting sustainable restoration efforts and agroforestry intensification programs.

The current Southeast Asian trend in which landscapes are moving away from swidden and agroforestry practices to industrial plantations could significantly impact biodiversity and ecosystem health. We recommend the following for future research:

i) Greater accountability of landscape metrics in assessing spatial interactions with biodiversity and ecosystem services, particularly in smallholder agroforestry systems, and how this can facilitate integrated management of agricultural landscapes.

ii) Review threshold studies in the context of landscape dynamics to increase our understanding of resilience in fragmented landscapes, and what role this has for restoration efforts.

Keywords: matrix, oil palm, resilience, restoration, mosaic.

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